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Art. III.—*The Place of the Genus* Styliolina *in the Palaeozoic Palaeontology and Stratigraphy of Victoria.*

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Contents.

Historical.

In 1904 Chapman (1904) described specimens of *Styliolina* from the Upper Yarra District as "*Styliola fissurella*, J. Hall, var. *multistriata*, var. nov." and figured a specimen which is now in the National Museum, Melbourne, as the type of the variety.

In 1912 Chapman (1912), describing fossils for the Geological Survey of Victoria, recorded "*Styliola fissurella*, J. Hall, var. *multistriata*, Chapm." from shale on the spur between Jordan River and B.B. Creek.

The following year Chapman (1913) referred the *Panenka-Styliola* beds to a new horizon, which he termed "Tanjilian." He considered this stage to be above the Yeringian series, and to be Upper Ludlow or Lower Devonian in age.

Chapman (1914) recorded the occurrence of "*Styliola fissurella* Hall, var. *multistriata* Chapm." from Howe's Creek Quarry, Loyola, near Mansfield.

Whitelaw (1916) described the geology of the Wood's Point District, and recorded the presence there of *Styliola fissurella* var. *multistriata*.

Kitson (1917) reported from the Powlett Plains District, South Gippsland, the presence in shales of pteropods like those of the Upper Yarra District. These were obtained from a bore at a depth of 660 feet, and were later identified by Chapman (1924) as *Styliola fissurella*, var. *multistriata*.

Junner (1920) grouped the beds of the Walhalla-Wood's Point District which contain *Styliolina* under the name "Panenka Beds" and gave their stratigraphical position as underlying the basal grit of the Walhalla Beds. Both the Panenka beds and the Walhalla beds he classified as "Yeringian (Upper Silurian)."

Chapman (1924) amplified his 1913 hypothesis of a Tanjilian stage above the Yeringian one, and after a discussion of the flora and fauna of the strata, expressed the view that they were almost certainly Devonian in age.

Skeats (1928) showed that the *Panenka-Styliola* beds are below the western basal grits (Yeringian) of the Walhalla Synclinorium, concluding that the Jordan River (Tanjilian) beds are therefore older and not younger than the Yeringian beds (as Chapman had asserted). Skeats proposed the discontinuance of the term "Tanjilian." He also recorded the occurrence of *Styliola* on the Thomson River.

Edwards (1932), when describing the rocks of the Warburton District, referred to the presence of *Styliola* in the Upper Yarra District.

Chapman and Thomas (1935), in a systematic description of the Silurian rocks of Victoria, supported the findings of Skeats (1928), but omitted the Tanjilian series from the sequence (p. 107).

Thomas (1939), in outlining the structure of the Palaeozoic rocks of Victoria, claimed that the *Panenka-Orthoceras-Styliola* association constitutes a reliable marker horizon. He mapped these beds with the Yeringian series.

In 1940 the author (1940) recorded *Styliolina* from Coldstream, a locality in the type Yeringian area.

Palaeontological.

History of the Genus Styliolina.

Until the year 1864, the fossils now accommodated in the genus *Styliolina* were called *Tentaculites*. In that year Professor Ludwig (1864) referred these smooth "Tentaculites" to the genus *Styliola* of Leseur. In the succeeding years Richter (*vide* Barrande, 1867), Barrande (1867), Hall (1879), and others referred these shells without annulations to *Styliola*, and so the genus became established in Palaeozoic palaeontology. In 1884 Karpinsky (1884) gave reasons for believing that the Palaeozoic Styliolae are distinct from the more recent forms, and he suggested for the former the name *Styliolina*. "*Styliolina* is distinguished from *Styliola* by the form of the embryonal bulb, the lack of longitudinal furrows and thorn-like processes about the stoma and the presence of longitudinal incised lines" (Clarke, 1885). This distinction is now generally accepted among palaeontologists.

Zoological Relationships of Styliolina and Tentaculites.

The relationship of these genera, and the classification of *Tentaculites* as a Pteropod, have been called in question by some (*vide* Reed, 1906, p. 124; Zittel-Eastman 1913, p. 569). Referring to the bulbous apex of *Tentaculites gracilistriatus*, Hall (1879, p. 174) wrote, "This minute bulb is so precisely like that . . . in recent forms of *Styliola*, that I cannot doubt that it is of precisely similar character and significance." The same author (p. 177) quoted Barrande as saying "These two genera seem then to disappear at the same time, which renders their reciprocal relations more marked." The possession of a bulbous protoconch by both these genera is an important structural link. Both these forms are pelagic and their environmental association should be noted. Shells of like proportions belonging to these genera, and in similarly immense numbers, are found associated in the same beds even when other fossils are apparently absent. We may infer that, because they thrived in the same environment even when other forms of life were reduced, that they were physiologically similar.

The genus *Tentaculites* is distinguished from that of *Styliolina* by its possession of annulations on the shell. The two genera, however, are not always easily separated. There are intermediate forms difficult of classification, such as *T. intermedius* Barrande (see also *Styliolina fissurella* var. *obsolescens* Hall).

Determination of the Victorian Form.

Styliolina is a genus difficult to divide into species satisfactorily. Barrande writes, "As a result of the diminutiveness of the forms named and the almost complete absence of ornament on their surface, one finds the chief difficulty is to establish their specific independence." Hall agrees (1879, p. 175). Because these shells have no specialized structure, almost the only data for specific separation are:—

1. Proportions of the shell.
2. Ornament on the shell.
3. Size of the shell.

1. The proportions of the shell seem to provide one of the surest means of distinguishing different species. Chiefly on this basis, for instance, Hall established his *Styliola obtusa* and *S. fissurella* var. *strigata* (Hall, 1879).

2. The ornament on the shell is sometimes significant, but generally is a rather variable character. Smooth, transversely striate, longitudinally striate, and both transversely and longitudinally striate forms are found in the same species, viz., *S. fissurella*.

The longitudinal fissure so often observed in *Styliolina* and the accompanying *Tentaculites* is commonly explained as a fracture or indentation produced by pressure in the rock. This explanation has been given by Hall (1879), Swartz and Prouty (1923, p. 490), and Prosser and Kindle (1913, p. 300). The shell-substance of *Styliolina* is very thin and therefore some degree of collapse is to be anticipated. It is noticeable that the fractures are usually in the centre of the shell as they appear on the surface of the rock. This can be explained as due to pressure operating vertically to the bedding plane. As often as not the fracture is on the upper surface of the shell. If this depression were natural, then it would be expected that the flatter, depressed side would come to rest on the sea-floor with the rounded side uppermost, and very rarely vice-versa. Some shells have the fracture on both upper and lower surfaces. Specimens occur in which the shell has not collapsed. The author has made sections of such a specimen from Muddy Creek, and observed a fully circular cross-section. (cf. Ludwig, 1864, "von rundem—nicht eckigem—Querschnitt.") Hall (1879), after referring to the fissure observed in the *Styliolina* shells collected from the shales, wrote, "When occurring in the calcareous bands, this feature is not characteristic."

3. *Styliolina* is usually a minute shell from two to three millimetres long, but a large form (about 45 mm. long) is recorded from the Middle Niagaran of America (Swartz and Prouty, 1923). In this case, size is a specific character. It is also a specific character of *S. spica* Hall (*vide* Grabau, 1889).

The specimens of *Styliolina* so far collected in Victoria apparently all belong to the same species. They agree in proportions, ornament (where present) and size with *S. fissurella* (Hall), a form having a very wide geographical distribution in North America. Chapman (1904) determined specimens of *Styliolina* from the Upper Yarra as *S. fissurella,* but regarded them as differing in a varietal manner from that species, and called them *S. fissurella* var. *multistriata.* He wrote: "The Victorian specimens cannot be separated specifically from Hall's *S. fissurella,* but differ from it in a varietal manner, by having the surface marked with very fine and regular transverse lines of growth. The American specimens are very variable as to ornament, but they do not show so constant a character in the lineation of the shell as do our specimens." The present writer doubts the validity of this variety. It should be noted that transverse striae on North American specimens of *S. fissurella* are common and characteristic, as the following quotations show:—

> "Annulated above and smooth near base." (Hall, 1843).
> "Surface often smooth and without any visible ornamentation so far as can be determined; or with fine striae of growth, which are unequally developed on different parts

of the shell; also with fine longitudinal striae, which may be present with or without transverse striae." (Hall, 1879, p. 178).

"Transverse and sometimes longitudinal striae." (Grabau, 1899).

"Surface smooth, marked only with fine lines of growth." (Grabau and Shimer, 1909).

"The Maryland specimens are smooth impressions except that the larger ones show very faint remains of transverse striae." (Prosser and Kindle, 1913).

Some of Hall's figures of transversely striated specimens of *S. fissurella* (*vide* Hall, 1879, Plate XXXI.A, figs. 4, 8, 10, 13, 15) are strikingly like our Victoria form. Chapman's figure (1904, Plate XXXI., fig. 4) shows the striations as very closely approximated to one another. The photomicrographs (Plate IV., figs. 2 and 3) accompanying this paper show that to be inaccurate. The spacing of the striae is comparable with that seen on Hall's Figs. 8, 13 and 15.

Hall describes a number of varieties of *S. fissurella*, but makes no variety dependable on ornament alone because this is so variable a feature. The present writer regards the striations on our Victorian specimens as but growth lines and of no special morphological significance.

Chapman (1904) regarded the transverse striations as a constant character. However, large numbers of specimens, collected from numerous localities, were examined, and were found to possess smooth more often than transversely striate surfaces. In view of the foregoing considerations, it is suggested that the variety lapse into synonymy with the species.

Hall (1879, p. 177) remarks that some specimens of *S. fissurella* are scarcely distinguishable from *S. clavulus* (Barrande). The Victorian forms of *S. fissurella* are mostly not so slender as the specimen of *S. clavulus* figured by Barrande (1867, Plate 14, figs. 28, 29) and taper fairly evenly to the apex, which the latter species does not do. Further, *S. clavulus* always has a smooth test, while the Victorian specimens sometimes have transverse striae. Nevertheless, like Hall, the author has observed specimens of *S. fissurella* which are difficult to distinguish from *S. clavulus*.

Faunal Associations.

Throughout the world *Styliolina* is usually accompanied by *Tentaculites* of like size and proportions, and in similarly large numbers. In U.S.A. the associated species with *S. fissurella* is generally *T. gracilistriatus* (Hall, 1879, etc.). In Canada *T. gracilistriatus*, *T. bellulus*, and *T. attenuatus* are recorded as in association with *S. fissurella* (Stauffer, 1915; Dyer, 1931; Fritz, 1939; etc.). In Cornwall *Tentaculites* sp. is recorded with

Styliolina sp. (Fox, 1900; 1905; etc.). In Bohemia *T. elegans* occurs along with *S. clavulus* (See Barrande, 1867, for Bohemia and other European areas). In the Northern Shan States *Styliolina* cf. *laevis* is associated with *T. elegans* and *T.* cf. *ornatus*. In Victoria *T. matlockiensis* Chapman is commonly found with *S. fissurella*. In addition *Panenka gippslandica* McCoy and various orthoceracones are characteristic faunal associates of *Styliolina* here in Victoria. Plant remains are also very common in the series, although they do not actually occur in the same bed as *Styliolina* in any locality, as far as is known.

Emended Description of *Tentaculites matlockiensis* Chapman.

The fossil described by Chapman (1904) as *Tentaculites matlockiensis* is a poorly preserved specimen, and the collection of well-preserved material now makes an emended description desirable. A hypotype (from Muddy Creek, Wood's Point Road, 11 miles east of Warburton) is now presented (Plate IV., fig. 5). The specimen is in the National Museum, Melbourne (Reg. No. 14089). Chapman's original description was as follows:—

"Shell conical, tapering, but broader at the open end than is usual in this genus. Shell substance thin, as in Styliola, but having distinct annuli, as in the typical forms of Tentaculites. Apical portion bulbous, sometimes apiculate, and occasionally with an overhanging flange. Margin of the orifice undulate, and with a vertical slit or sinus in a line with the median depression of the shell-surface. A transverse section of the shell shows it to be thinner in the neighbourhood of this depression, and the example figured has a tubular enclosure which has the appearance of a small siphuncle or ventral canal. The proximity of this tube to the wall of the shell seems, however, to be unfavourable to the idea of its relationship to the Cephalopoda, to which it might otherwise point. On the other hand examples are not unknown where a smaller shell is found enclosed in an adult specimen, and from the relative diameter of our section, the slice was apparently taken across the shell, not far from its apical end, where the enclosed shell would have a much smaller diameter. The first third of the shell is generally smooth, afterwards becoming annulated with thin salient ridges, the intercostal spaces being concave. The annuli cease near the marginal extremity, and the shell-surface bears numerous, vertical, superficial wrinklings pointing to an affinity with the vertically striated species of the genus."

Description of hypotype: Shell minute, acicular cone, tapering from the stoma to the apex rather slowly for the first third of length of shell, then more rapidly for the remainder. Circular in cross-section, thin-shelled (so that the specimens are usually crushed, displaying a fissure similar to that in the accompanying *Styliolina* shells). About 70 rounded annulations which are wider than the interspaces so that the mould shows thin ridges between the troughs formed by the annulations. Annulations more crowded at apical end than at stomatic end.

Comment: The margin of the orifice is not undulate as originally described, the unevenness of the margin being due to the incompleteness of the specimen. The type (Plate IV., fig. 1) is apparently an internal cast—hence the smoothness of part of

the shell and the faintness of the annulations. Comparison may be made with the photomicrograph reproduced with this paper (Plate IV., fig. 4). The stomatic end of this specimen shows the internal cast, while the breaking away of the cast reveals the external mould at the apex. On the same slab as the type specimen and on another slab on the same plaque in the National Museum there are impressions of shell-fragments showing clearly the typical ornament of the species as referred to in the emended description. There are also poorly preserved specimens of *Styliolina fissurella*.

Tentaculites matlockiensis is of similar size and proportions to *S. fissurella* and it occurs in similarly large numbers with it. The species is comparable with *T. elegans* Barrande in size and proportions. However, *T. matlockiensis* has much more numerous annulations, and the characteristic longitudinal striation of Barrande's species is absent. The more numerous annulations on a shell of similar size means also that the interspaces are different in the Victorian species from those of the Bohemian species. Besides its occurrence in Europe, *T. elegans* is known from Burma (Reed, 1906, pp. 124-125).

T. matlockiensis may also be compared with *T. gracilistriatus* Hall which is a frequent associate of *S. fissurella* in North America. In *T. gracilistriatus* the annulations are subequidistant, those towards the apex being more distant and more subdued. In *T. matlockiensis* the annulations are crowded near the apical end and are not subdued. *T. gracilistriatus* has the apical portion of the shell smooth and is ornamented with longitudinal striations. *T. matlockiensis* has annulations right to the apex, and no longitudinal striations have been observed.

T. bellulus Hall is another North American species which occurs with *S. fissurella* in that continent. It differs from Chapman's species in being much more attenuate, in having a smooth apical portion, and in possessing acute annulations.

Stratigraphical.

Occurrence and Range of *Styliolina* beyond Victoria.

Styliolina occurs in rocks of both Silurian and Devonian ages. A large form occurs in the Middle Niagaran of Maryland (Swartz and Prouty, 1923). La Touche (1913) records the genus from the Silurian of the Northern Shan States. Mansuy (1916, 1919) records it from the Devonian of French Indo-China. *Styliolina* occurs in the Devonian of United States of America (Hall, 1879, etc.), Canada (Dyer, 1931; Fritz, 1939; etc.), England (Fox, 1900, 1905, etc.), and the continent of Europe (Barrande, 1867, etc.).

Occurence of *Styliolina* in Victoria.

Styliolina fissurella (Hall) is known from the following localities in Victoria:

1. Railway cutting, Coldstream (Gill, 1940). Chapman (1924, p. 318) has noted scattered specimens in the Lilydale shales. The writer has collected such from Melbourne Hill and Mitchell's Paddock in that same area. *Tentaculites matlockiensis* was also found in the Mitchell's Paddock outcrop. The Coldstream locality, however, is a definite *Styliolina* band with the specimens in immense numbers.

2. Warburton Highway, Killara, in a cutting about $\frac{1}{4}$ mile east of the turn-off to Killara Railway Station. New locality.

3. "Mouth of Starvation Creek" (Chapman, 1904).

4. Muddy Creek, in a road cutting on the Wood's Point road on the west side of the creek. New locality.

5. Between Muddy Creek and McMahon's Creek Village. New locality.

6. McMahon's Creek (Chapman, 1904). This locality was on a steam tram line now out of use. The Wood's Point road was not then constructed.

7. Cutting on Wood's Point road a short distance east of the quarry containing plant remains at Yankee Jim Creek. New locality. This is near the site of the former village of Reefton.

8. Eighteen-mile Quarry (i.e., east of McVeigh's), Yarra Track (Thomas, 1939).

9. Spur between Jordan River and B.B. Creek (Chapman, 1912; Whitelaw, 1916).

10. Mt. Matlock. New recording.

11. Near Platina (Chapman, 1924).

12. Erica District (Chapman, 1924). Mr. Baragwanath informs me that this locality is on the Walhalla-Erica railway line about 3 miles east of Erica, near Cooper's Creek.

13. Thompson River, near Machinery Spur. The locality is 5 chains east of the Thompson River and 20 chains south of the Quarter Sheet boundary (Skeats, 1928).

14. Howe's Creek Quarry, Loyola (Chapman, 1914).

15. Yea-Alexandra District. Dr. Harris and Messrs. Keble and Thomas found *Styliolina* in this area, but the occurrence has not been previously recorded.

16. Powlett River bore (Kitson, 1917; Chapman, 1924).

17. West of Yankee Jim Creek.

Stratigraphical Range of *Styliolina* in Victoria.

Styliolina fissurella is very widely distributed in the North American continent, and its presence in Victoria supports the theory of a Palaeozoic Pacific Ocean postulated by Ruedemann (1911; 1927; 1934, p. 22) and others. In addition to this fossil there are many other species in the Victorian "Silurian" (part of the so-called Silurian no doubt belongs to the Devonian) which are the same as, or comparable with, those found in the North American Silurian and Devonian formations. The following have been noted:—

Actinopteria boydi (Conrad).
Anoplia sp.
Atrypa aspera (Schlotheim).
A. hystrix Hall.
A. reticularis (Linnaeus).
Atrypina imbricata (Sowerby).
Bythotrephis gracilis Hall.
B. tenuis Hall.
Calymene blumenbachi (Brongniart).
C. nodulosa (Shirley) = *C. tuberculosa* Salter non Dalman.
Coelospira hemispherica (Sowerby).
Cycloceras bullatum (Sowerby).
Cyrtinopsis perlamellosus (Hall).
"*Dalmanella*" *testudinaria* (Dalman).
Delthyris crispa (Hisinger).
D. sulcatus (Hisinger).
Edmondia perobliqua Chapman cf. *E. obliqua* Hall.
Eospirifer plicatellus (Linnaeus).
Favosites basaltica Goldfuss.
F. gothlandicus Lamarck.
Goniophora glaucus Hall.
Grammysia arcuta Conrad.
G. plena Hall.
Haliserites dechenianus Göppert.
Heliolites interstinctus Goldfuss.
Leiopteria oweni Hall.
Leptaena rhomboidalis (Wilckens).
Lingula lewisi Sowerby.
Modiolopsis nasuta Conrad.
Monograptus dubius (Suess).
M. priodon (Bronn).
Nucula lamellata Hall.
N. lirata Conrad.
N. opima Hall.
Palaeantina solenoides Hall.
Palaeoneilo brevis Hall.
P. constricta Conrad.
P. tenuistriata Hall.
Parmorthis elegantula (Dalman).
Plagiorhyncha decemplicata (Sowerby).
Platyceras erectum Hall.
Plectambonites transversalis Wahlenburg.
Retiolites (*Cladiograptus*) *geinitzianus* Barrande.
Rhynchotreta cuneata Dalman.
Stromatoporella granulata Nicholson.
Tancrediopsis spectabilis (Chapman) cf. *T. altistriata* McLearn.
Uncinulus stricklandi Sowerby.

This list can be extended when the faunas of other Australian States and of New Zealand are considered (Vide De Koninck, 1898; Shearsby, 1911; Allan, 1935; Shirley, 1938; Gill, 1939, etc.). Thus *Styliolina fissurella* is only one of a large group of fossils which demonstrates the faunal connexion between the Siluro-Devonian beds of Australasia and those of North America.

In North America *Styliolina fissurella* occurs in strata of Middle and Upper Devonian age. In Victoria it occurs in beds of much earlier age, having been found interbedded with *Monograptus* (Skeats, 1928, p. 229). It is interesting to compare a similar occurrence in the Northern Shan States (La Touche, 1913), where *Styliolina* cf. *laevis* is associated with *Monograptus riccartonensis*. In Victoria, *Styliolina* has also been found in the type Yeringian area (Gill, 1940) on approximately the same strike as the limestone of Cave Hill to which Ripper (1938) and Hill (1939) have attributed a Devonian age. Thus *Styliolina* has quite a long time-range in Australia as it has in North America, but in a lower geological sequence. The early appearance of *S. fissurella* in Victoria, compared with its occurrence in North America, is a character observed in some other Victorian forms. Vascular land plants occur associated with *Monograptus* (Lang and Cookson, 1935). Some brachiopods (e.g., *Anoplia*) occur earlier here than they do elsewhere. These facts invite the theory that for some forms at least Australia was a Palaeozoic evolutional distributing centre (cf. Reed, 1906, p. 179; Chapman, 1908, p. 8).

When first dividing the "Silurian" of Victoria into Melbournian and Yeringian series, Gregory (1903) included the *Panenka-Styliolina* beds of the Upper Yarra district in his Melbournian division. Chapman (1914, 1924) included these strata in his Tanjilian series, which he regarded as younger than the Yeringian and probably Devonian in age. Skeats (1928) has shown the Tanjilian series to be older and not younger than the Yeringian series. Chapman and Thomas (1935) agreed with Skeats, but omitted the Tanjilian series from the "Silurian" sequence, apparently including it with the Yeringian series. Thomas (1939), in mapping the structure of the Lower Palaeozoic rocks, included the *Styliolina* beds with the Yeringian. He also stated that the *Styliolina-Panenka-Orthoceras* association provides a good marker horizon. Chapman (1913, p. 212) described his Tanjilian series as follows: "This series comprises the Panenka shales of Mt. Matlock, and Reefton, near Warburton. In the Walhalla District the Panenka shales of the Jordan River series lie on the Walhalla geosynclinal, and abut on Upper Ordovician graptolite beds. . . . Should the stratigraphical evidence prove this to belong to a distinct stage in Victoria, I would suggest the term Tanjilian, since the Panenka shales are well developed in the district of the Tanjil River, Gippsland."

There is here no clear indication of which outcrop is to be regarded as the type area of the Tanjilian, unless it be that from which the name is derived. The only locality in the Tanjil River area is that mentioned by McCoy (1879), viz., Russell's Creek, which is a tributary of the Tanjil River. McCoy gives that place as a locality at which *Panenka gippslandica* is "common." Mr. Baragwanath, the director of the Geological Survey of Victoria, is of the opinion that the specimens concerned came, in fact, from McMahon's Creek. The Russell's Creek Mining District reaches as far as the headwaters of McMahon's Creek. Murray (1916) claimed to have collected the specimens referred to by McCoy, but he does not mention them in his two earlier reports (1876, 1880), and when he was making the re-survey described in his 1916 report, Mr. Baragwanath inquired about the Russell's Creek locality, but Mr. Murray was unable to say where it was. The fossils are recorded (Murray, 1916) as coming from a tunnel, but no tunnel has been located on Russell's Creek. The nearest known tunnel is one under the basalt about 1½ miles south of where Russell's Creek joins the Tanjil River. This is described in Progress Report No. 6 of the Geological Survey of Victoria. Further, it is to be noted that *Styliolina* has not yet been collected from there (*Contra* Chapman and Thomas, 1935, p. 108). Furthermore, the "Tanjilian" as re-defined in this paper is not co-extensive with the series described by Chapman (the Monograptus Beds are removed), and the name "Tanjilian" itself is associated with an error of sequence. The cumulative force of the foregoing considerations seem to provide good practical grounds for adopting Skeat's suggestion of abandoning the name "Tanjilian." I propose therefore that the name "Jordanian" be substituted, as beds of the *Panenka-Styliolina* association have been fully proved and accurately mapped in the Jordan River area (Whitelaw, 1916; Junner, 1920; Baragwanath, 1925; Skeats, 1928). I propose also that the locality "between Jordan River and B.B. Creek" be the type locality for the Jordanian. As already stated, I do not propose that the Jordanian be co-extensive with the Tanjilian of Chapman. Junner (1920), dealing with the beds which Chapman called Tanjilian, separated the *Monograptus* beds from the *Panenka* beds, referring the former to the Melbournian series and the latter to the Yeringian series. The distinction is a sound one. Whitelaw (1916), in the caption of his map of the Wood's Point District, distinguished between—

1. Yellow silky mudstones with *Panenka*, etc.
2. Black slates with *Monograptus* sp.

Hall (1906, 1907) has recorded the following graptolites from the beds called Tanjilian by Chapman:—

Monograptus cf. *crenulatus.*
M. dubius.
M. cf. *jackeli.*
M. sp. (*colonus* type).

Chapman (1924) included these doubtfully in his list of Tanjilian fossils. Chapman and Thomas (1935) have suggested that they point to a Melbournian age. Recently, Harris and Thomas (1939) have identified the following forms from the Yarra Track:—

Monograptus uncinatus var. *orbatus.*
M. uncinatus var. *micropoma.*
M. vomerinus.
M. vomerinus var. *crenulatus.*

M. dubius and *M. colonus* are known from the Melbournian of Melbourne itself (Thomas and Keble, 1933). The two varieties of *M. uncinatus* have both been recorded from the Melbournian beds at Heathcote (Harris and Thomas, 1937). *M.* cf. *vomerinus* has been collected from beds of Melbournian age near Yass, New South Wales (Sherrard and Keble, 1937). *M. jackeli* and *M. vomerinus* var. *crenulatus* are not known from any other locality in Australasia (vide Keble and Benson, 1939). The foregoing evidence persuades me that some at least of the *Monograptus* beds are Melbournian. The *Monograptus* beds appear to be comformable with the Mt. Easton Ordovician strata and so Keilorian beds are to be expected between the Ordovician and Melbournian (as re-defined by Thomas and Keble in 1933). Chapman and Thomas (1935) record Keilorian graptolites "including *Monograptus aplini* and *Stomatograptus australis*" from the Jordan River series.

I propose, therefore, that the "Silurian" succession in Victoria be recognized as follows:—

4. Yeringian (youngest).
3. Jordanian.
2. Melbournian.
1. Keilorian.

It will be observed that the Jordanian series is more restricted than the Tanjilian series of Chapman.

Besides having a characteristic palaeontology, the Jordanian series has a characteristic lithology. The sediments consist mainly of shales (many of which are finely laminated) and of massive felspathic sandstones. Neither of these latter types of rock can be considered characteristic of either the Melbournian or the Yeringian series. They are absent from the Melbournian and Yeringian type areas. Limestones, which are characteristic of the Yeringian, are absent from the Jordanian.

The following Styliolina localities are regarded by the author as Yeringian:—

1. Railway cutting, south of Coldstream railway station.
2. Warburton highway, Killara.
3. West of Yankee Jim Creek.

This locality is about half a mile west of Yankee Jim Creek and 15½ miles east of Warburton on the Warburton-Wood's

Point road. Clear sections are to be seen on the road and on the aqueduct above the road. There are also outcrops on the river banks below the road. The locality represents a Yeringian outlier and possibly the centre of the synclinorium termed by Thomas the McVeigh Synclinorium (Thomas, 1939). The rocks are closely folded, with crush zones and minor faulting. There is a dyke showing on the aqueduct section. On the same section two anticlines and two synclines (*vide* text-figure 1) can be seen in 300 yards, whereas elsewhere the structure consists of broad open folds. This locality occurs between westerly dipping Jordanian beds at Yankee Jim Creek and easterly dipping

Fig. 1.—Syncline in closely-folded strata shown on aqueduct cutting west of Yankee Jim Creek, Upper Yarra District.

Jordanian beds at McMahon's Creek. This outlier gives corroborative evidence to Skeats' paper (1928), which describes the "Tanjilian" beds as underlying and not overlying the Yeringian series, as was originally suggested (Chapman, 1924). From the aqueduct and road cuttings (*in situ* and from loose rock) the following fossils have been collected:—

cf. *Hostimella* sp. Abundant.
Zosterophyllum australianum Lang and Cookson.
Styliolina fissurella (Hall). A solitary individual. The species occurs thus at Lilydale.
Spirifer of the *lilydalensis* Chapman type. Abundant.
Anoplia, sp. nov. Abundant. *Vide* Gill, 1940.
Beyrichia cf. *kloedeni* McCoy. *Beyrichia* is not known from the Jordanian but is abundant in the Yeringian.
Tubuliporinid bryozoan (cf. *Reptaria*).
Fenestella cf. *margaritifera* Chapman.
Crinoid stem joints. Common. Crinoids are not common in the Jordanian but are abundant in the Yeringian.

It has been noticed in the localities examined that in Yeringian outcrops *Styliolina* is restricted to narrow bands or occurs as isolated individuals, whereas in the Jordanian it occurs in great numbers through great thicknesses of rock.

Recently, the author (Gill, 1940) discussed the extent of the Yeringian rocks between Lilydale (type area) and Melbourne (type area of the Melbournian). Subsequent work has shown that there is a band of conglomerate north of Ringwood ($\frac{1}{4}$ mile west of where the five roads meet on the Ringwood-Warrandyte road) which has decalcified corals, bryozoa, brachiopods, and crinoids, such as are found in the Lilydale district. This conglomerate is probably the base of the Yeringian. This new locality is the southerly extension of the conglomerate mapped by Jutson (1911). It is seen on his map (plate XCII.) along the Consols and 5th Hill anticlines, which are subsidiary structures on the Warrandyte anticlinorium. In places the conglomerate gives way to a heavy sandstone or grit with inclusions of mudstone. A similar rock is found west of Yankee Jim Creek containing the Yeringian fossils already named. The *Spirifer*, *Fenestella*, crinoid fragments, and Tubuliporinid bryozoan are common to both localities.

Whether Jordanian rocks occur between the Yeringian conglomerate north of Ringwood and the Melbournian rocks further west has yet to be discovered. It should be noted that *Panenka* cf. *cingulata* Chapman has been found at One Tree Hill some miles north on the same Warrandyte anticlinorium (Chapman, 1908). Mr. R. B. Withers and the author found in a small road cutting just outside the Watson's Creek State School (north of Warrandyte) specimens of *Anoplia* (which show that the beds are probably Yeringian) and a pelecypod referable to the genus *Posidonomya*. This genus is unknown from the Yeringian strata, but it is not uncommon in the Jordanian beds between Muddy Creek and the McMahon's Creek village in the Upper Yarra District, west of the Yeringian outlier. The presence of *Anoplia* and *Posidonomya* at Watson's Creek suggests an early Yeringian age, i.e., not far removed from the Jordanian. This view is consistent with the structure of the area as at present known. That the Jordanian series represents a definite time-period and not just a facies synchronous with the Yeringian elsewhere is shown by the structure of the Walhalla synclinorium where Jordanian rocks appear between the Melbournian graptolite beds and strata with typical Yeringian fossils. The interposed Jordanian series helps to explain the great dissimilarity between the Melbournian and Yeringian faunas. Chapman (1913) writes, "In the Melbournian division, 136 fossil forms are recorded; whilst in the Yeringian there are no less than 206 species. . . . Of the Melbournian and Yeringian series, only sixteen species are in common, showing the division between the two to be well marked, and probably separated by a distinct geological pause in sedimentation." The figures now are approximately—Melbournian, 137 species (this figure is almost the same because, although new forms have been added to the fauna, some localities previously regarded as Melbournian are now classified as Yeringian),

Yeringian, 259 species, and common to both series, nineteen species. A large number of Yeringian forms awaiting description further accentuate the difference between the Melbournian and Yeringian faunas. However, the presence of *Panenka* and *Posidonomya* north of Warrandyte shows that possibly there are Jordanian rocks between the basal conglomerate described above and the Melbournian beds further west. The unfossiliferous character of the rocks makes the determination of this point most difficult. Another possibility is that the Jordanian beds thin out so as not to appear at the surface in this area, as is the case with the Mt. Useful beds on the western side of the Walhalla synclinorium (*vide* Skeats, 1928, pl. II.). The boundary between the Melbournian and Yeringian would then be a disconformity.

The following *Styliolina* localities are regarded by the author as Jordanian:

1. Between Jordan River and B.B. Creek. Type locality for the Jordanian series.
2. Erica District (Chapman, 1924).
3. Eighteen-mile Quarry (i.e., east of McVeigh's), Yarra Track.
4. East of Yankee Jim Creek.
5. McMahon's Creek (Chapman, 1904).
6. Between Muddy Creek and McMahon's Creek village.
7. Muddy Creek (west bank beside Warburton-Wood's Point road).
8. Starvation Creek.
9. Mt. Matlock.
10. ? Powlett River bore.
11. ? Howe's Creek Quarry, Loyola.

The following localities are regarded by the author as Melbournian:

1. Nineteen-mile Quarry, Yarra Track. The author has collected with *Monograptus* the following forms:—

Baragwanathia longifolia Lang and Cookson.
Yarravia oblonga Lang and Cookson.
Pterygotus sp.
Orthoceras sp.
Ceratiocaridae indet.

2. Twenty-mile Quarry, Yarra Track. At this locality the author has collected *Monograptus* and plant remains. Harris and Thomas (1937) record from here *Monograptus vomerinus* and *M. vomerinus* var. *crenulatus*.

3. Thompson River, near Machinery Spur (Skeats, 1928).

From the foregoing list of localities it may be seen that *Styliolina* ranges in Victoria from the Melbournian through the Jordanian to the Yeringian.

Systematic List of Jordanian Fossils.

The numbers following the names of the fossils are the numbers of the Jordanian localities listed above. The fossils marked with an asterisk are new recordings, and the specimens are in the writer's collection.

PLANTAE:

cf. *Hedeia corymbosa* Cookson.—3*.
cf. *Hostimella* sp.—Yankee Jim Creek*.
Zosterophyllum australianum.—3*; Yankee Jim Creek*; 10½ mile Quarry, Yarra Track*.
Indeterminate plant remains are found at numerous localities.

ANTHOZOA:

Heliolites sp.—Yankee Jim Creek*.

CRINOIDEA:

Small stem joints.—7*; Yankee Jim Creek*; 9 mile Quarry, Yarra Track*.

ANNELIDA:

Cast of tube.—10½ mile Quarry, Yarra Track*.

BRACHIOPODA:

Athyris sp.—6*, 7*.
Atrypa sp.—7*.
Chonetes sp. nov.—6*.
Cyrtina sp.—6*.
Lingula sp.
Orbiculoidea sp.—6*

PELECYPODA:

Actinopteria sp.—1.
Lunulicardium antistriatum Chapman.—5, 9, "Reefton."
Panenka cingulata Chapman.—5.
P. gippslandica (McCoy).—1, 2, 3, 4*, 5, 8, 9.
P. planicosta Chapman.—9.
Panenka sp. nov. (?).—6*.
Paracardium filosum Chapman.—8.
? *Paracardium* sp.—1.
Posidonomya sp.—6*.
Sphenotus warburtonensis Chapman.—"Reefton."

GASTEROPODA:

cf. *Euomphalus* sp.—8 mile Quarry, Yarra Track*.
Hercynella, sp. nov.—7*.
Zygospira sp.—7*.

PTEROPODA:

Coleolus aff. *aciculum* Hall.—7*.

Hyolithes sp.—7*.

Styliolina fissurella (Hall).—1, 2, 3, 4*, 5, 6*, 7*, 8, 9*, 10, 11.

Tentaculites matlockiensis Chapman.—1, 3*, 4*, 6*, 7*, 9.

Tentaculites sp. (large).—8 mile Quarry, Yarra Track*.

CEPHALOPODA:

Kionoceras cf. *striatopunctatum* Munster.—10.

Orthoceras spp.—1, 3, 4*, 5, 6*, 7*.

PHYLLOCARIDA:

Ceratiocaris sp.—1.

Summary.

1. A critical discussion of the genus *Styliolina* is given, and the Victorian specimens determined as *S. fissurella* (Hall).

2. Data are provided concerning the faunal associations of *Styliolina*, and *Tentaculites matlockiensis* Chapman is redescribed.

3. *Styliolina fissurella* is shown to have a long geological time-range in Victoria (as it has in North America), but at an earlier period, viz., Melbournian—Jordanian—Yeringian, which is Lower Ludlow to Lower Devonian.

4. The "Tanjilian" series of Chapman is critically discussed and the Jordanian series proposed. A systematic list of Jordanian fossils is provided. A Yeringian outlier in the Upper Yarra District is recorded. A fossiliferous conglomerate which is probably the base of the Yeringian is recorded from north of Ringwood.

Acknowledgment.

I wish to thank Mr. W. Baragwanath, the Director of the Geological Survey of Victoria, for placing at my disposal his intimate knowledge of the Walhalla-Wood's Point area. Dr. T. C. Cookson kindly determined the plants for me. I have also appreciated the kindness of Mr. D. Thomas, B.Sc., and Mr. R. B. Withers, M.Sc., Dip.Ed., in discussing with me a number of the points raised in this paper. The photomicrographs are the expert work of Mr. L. A. Baillôt of the Melbourne Technical College, except one, for which I owe thanks to Mr. F. Chapman, A.L.S.

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Explanation of Plate.

PLATE IV.

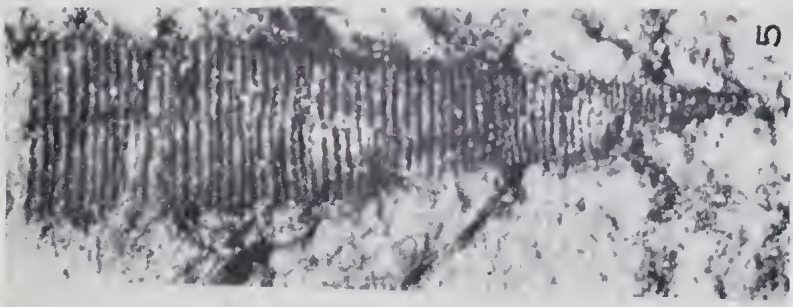
Fig. 1.—Photomicrograph of *Tentaculites matlockiensis* Chapman. Type specimen, National Museum, Melbourne.

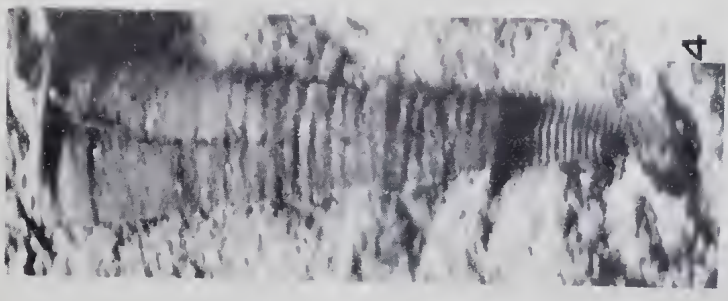
Fig. 2.—Photomicrograph of *Styliolina fissurella* (Hall). Type specimen of Chapman's variety *multistriata.*

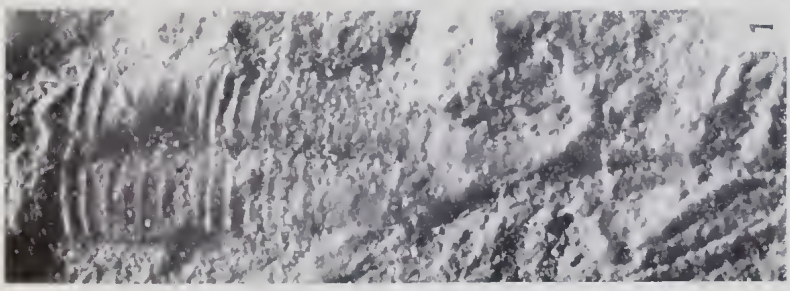
Fig. 3.—Photomicrograph of *S. fissurella* taken by Mr. F. Chapman. Note faint striae at stomatic end.

Fig. 4.—Photomicrograph of *Tentaculites matlockiensis.* Internal mould with external cast showing at apical end.

Fig. 5.—Photomicrograph of *T. matlockiensis* hypotype from Muddy Creek, Upper Yarra District, National Museum reg. no. 14089.







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[Proc. Roy. Soc. Victoria, 53 (N.S.), Pt. I., 1941.]

Art. IV.—The Silurian Rocks of the Studley Park District.

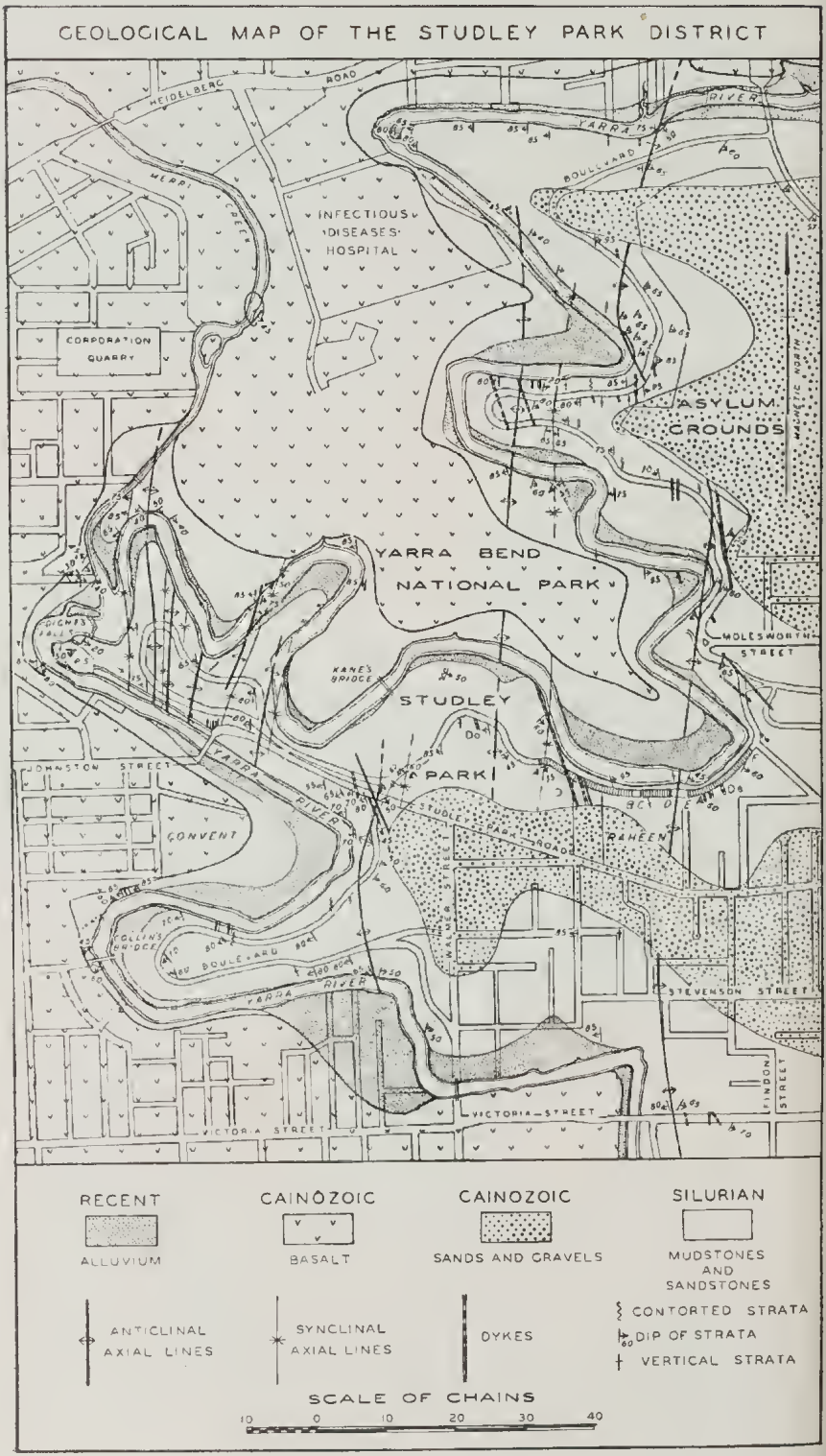
By EDWIN SHERBON HILLS, Ph.D., D.Sc.

[Read 13th June, 1940; issued separately 1st February, 1941.]

Contents.

Introduction.

The construction of the Yarra Boulevard between Studley Park and Fairfield recently afforded an excellent series of road sections, which the author took the opportunity of investigating while constructional work was in progress, in order to elucidate the complex folding, faulting, and other structural features exhibited by the Silurian strata that form the bedrock of the district. The sections available for detailed study, including the river banks and excavations for roads and tracks, amounted to upwards of 12 miles, although the Silurian rocks occupy only about one square mile in the area mapped. This area is included in quarter-sheet No. 1, N.E. (Melbourne), of the Geological Survey of Victoria, and also in Miss Nicholls' map of the axial lines of folds in the Silurian rocks in the eastern suburbs of Melbourne (Nicholls, 1930). The data available to the present author indicate that the structural information as to dips, strikes, and folds shown on both these maps is unreliable, but only minor changes have had to be made in the geological boundaries on the quarter-sheet. In spite of careful and repeated examination of every outcrop and section, however, it was found impracticable to map all the minor folds, especially in the "crush zone" between Johnston Street Bridge and Dight's Falls. In general, the chief axial lines shown on the map (fig. 1) have been located accurately in the field over considerable distances, though in a few places the delineation of major structures is still somewhat uncertain. For information concerning the general geology of the district the paper by Hauser (1923) may be consulted, the present contribution being concerned only with the Silurian rocks, and the dyke intrusions that penetrate them.


GEOLOGICAL MAP OF THE STUDLEY PARK DISTRICT
HEIDELBERG ROAD
YARRA RIVER
BOULEVARD
MERRI CREEK
INFECTIOUS DISEASES HOSPITAL
CORPORATION QUARRY
ASYLUM GROUNDS
NORTHCOTE
YARRA BEND NATIONAL PARK
MOLESWORTH STREET
KANE'S BRIDGE
STUDLEY PARK
JOHNSTON STREET
CONVENT
STUDLEY PARK ROAD
RAHEEN
WALMER STREET
COLLINS BRIDGE
STEVENSON STREET
WINDSOR STREET
VICTORIA STREET
RECENT
ALLUVIUM
CAINOZOIC
BASALT
CAINOZOIC
SANDS AND GRAVELS
SILURIAN
MUDSTONES AND SANDSTONES
ANTICLINAL AXIAL LINES
SYNCLINAL AXIAL LINES
DYKES
CONTORTED STRATA
DIP OF STRATA
VERTICAL STRATA
SCALE OF CHAINS
10 0 10 20 30 40

Palaeontology.

Fossils have previously been obtained from the track to the Pumping Station (*P.S.* on the map, near Dight's Falls) and also from the spur above the Falls. Hauser listed *Monograptus* sp., cf. *Streptelasma*, *Camarotoechia decemplicata*, *Chonetes melbournensis*, and *Loxonema* sp. from these localities, and Jones (1927) recorded *Monograptus chimaera*, *M. roemeri*, *M. colonus*, and *M. varians* from the track to the Pumping Station. Harris and Thomas (1937) determined *M. crinitus* from this section, and Withers and Keble (1934) described a new species of brittle-star, *Furcaster bakeri*, in a collection made by Mr. G. Baker from the loop in the Boulevard north of Johnston Street Bridge. The Rev. E. D. Gill has kindly examined Mr. Baker's collection and also fragmentary shelly fossils obtained by me from the foundations of a pylon north-west of Victoria Bridge, from the northerly extension of these beds on Studley Park Road, and from sewerage excavations in Kevin Street; he has supplied the following list of forms so far identified from the Studley Park district:

PLANTAE:	*Bythotrephis divaricata* Kidston, *B. tenuis* Hall.
COELENTERATA:	cf. *Streptelasma*, *Monograptus chimaera* (Barrande), *M. colonus* (Barrande), *M. roemeri* (Barrande), *M. varians* Wood, *M. crinitus* Wood.
ANNELIDA:	*Keilorites* sp.
ARACHNIDA:	*Hemiaspis tunnecliffei* Chapman.
MOLLUSCA:	*Pleurotomaria* sp., *Loxonema* sp., *Hyolithes* sp.
BRACHIOPODA:	*Chonetes melbournensis* Chapman, *Nucleospira australis* McCoy, *Plagiorhyncha decemplicata* (Sowerby), *Rhynchatrema liopleura* McCoy, *Spirifer* sp. nov. (?).
ECHINODERMATA:	*Furcaster bakeri* Withers and Keble, *Sturtzura brisingoides* (Gregory), Crinoid stem joints.

In spite of careful searching along the excellent sections north of the tunnel beneath Studley Park road, no fossils have been obtained in this part of the area, and the palaeontological data now available necessitate no change either in the earlier reference of the strata to the Melbournian Series, or their correlation with the *M. nilssoni* Zone of the Ludlovian of Great Britain (see Jones, 1927; Chapman and Thomas, 1935).